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Wearables beyond borders: A case study of barriers to gait assessment in low-resource settings

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Abstract:

Currently, there are major EU-based projects to better utilise wearables as useful diagnostic aids/tools in clinical settings as well for deployment in the home to capture ageing processes. To date, there has been little investigation of the translation of those tools beyond the geographical regions in which they were developed and implemented. Our objective was to examine pragmatic issues and challenges in the use of wearables in a diverse, low-resource, middle-income country like Brazil. We found barriers to their understanding and adoption con-verge on three themes: (i) regional inequalities; (ii) knowledge and resources; and (iii) trust. Current large-scale projects should consider the scalability and implementation of their methods, given those themes, facilitating a stratified and global approach to healthy ageing

1.0 Introduction

It is estimated that by 2030 the number of people suffering from Parkinson's disease (PD) will be approximately 9 million globally based on Western Europe's (e.g. the United Kingdom, <50% growth) and the rest of the world's most populous nations (e.g. Brazil, >100% growth) [1]. Yet, robust screening and reporting of PD in developing countries is not mainstream, which may result in underestimated numbers. Motor symptoms (e.g. impaired performance of voluntary movements like walking/gait) have greatest impact on PD-associated costs at almost US$6000/patient in a developing country like Brazil [2] where many may remain undiagnosed and untreated [3]. Those receiving early diagnosis can obtain therapeutic interventions to reduce motor symptoms. In Brazil several such services are offered to patients at zero or reduced costs by some cities, associations exclusively dedicated to aid PD patients, but these services often fail to reach their target audience [2]. Perhaps this has been due to a lack of pragmatic diagnostic tools for more robust health technology assessment [4].

Wearable technologies (wearables) are reshaping healthcare and transforming approaches to how patients should be diagnosed, treated and managed. Wearables are enabling healthcare professionals to break free from the shackles of traditional approaches to assessment, monitoring beyond the clinic [5]. Habitual assessment with wearables can provide objective, continuous data, revolutionising approaches to common practise compared to snap shot, clinical assessments [6]. Yet, handling large wearable/digital-based data creates pragmatic challenges such as interpreting raw data and selecting suitable (bio) markers during discrete moments of clinical interest from continuous streams of big data [7]. Moreover, although wearables are emerging as useful screening/diagnostic tools in pathology, no standard methodologies exist to guide validation/verification processes which has implications for deployment, raising questions about devices being fit-for-purpose [8]. This has stifled pragmatic use of wearables on a global scale as lack of progression in resource-rich/developed regions (e.g. UK) has connotations for a low-resource/developing country like Brazil where calls for sustainable health assessment technology strategies have been made [9].

Recently, low-cost inertial wearables have leapt to clinical attention within ageing studies by enabling quantification of functional activities, e.g. gait [10]. The latter is being used to investigate habitual-based digital (bio) markers in diagnostic and predictive medicine [5]. Recent launch of large European multisite studies such as Mobilise-D [11], a collaboration between academia and the pharmaceutical industry to deliver a valid solution for real-world mobility through wearable gait assessment, is seen as a game changer. However, technologies stemming from global pharmaceutical corporations based in resource-rich countries tend not to be developed for exclusive use in low-resource settings [12]. Therefore, *what challenges would future wearable-based gait assessment tools face when used beyond the geographical regions in which they are developed?* Considering a developing economy like Brazil, obvious barriers to adoption may include integration to information and communication technology infrastructures, which although still limited, have advanced in recent years [13].

Here, we aim to identify practical functional challenges for healthcare professionals facing adoption of wearables as gait assessment tools beyond the borders where they are created and developed. We focus on low-resource settings by examining a case study of a middle income country[1], Brazil.

2.0 Methods

A qualitative study design was used to gain insight into basic challenges associated with inertial-based wearable adoption for pragmatic use in clinical and research settings in Brazil. Semi-structured interviews using open-ended questions were undertaken with clinical and research staff (Supplementary material, Appendix A). Rigour in the design and reporting of the study is based on the RATS framework [14]. Two bilingual (Portuguese and English) volunteers were chosen at random from staff within the Department of Physical Education and healthcare professionals of geriatric medicine from São Paulo State University (Universidade Estadual Paulista, UNESP). The pool of volunteers includes academic and clinical staff affiliated to a human motion laboratory with interests in neurological movement disorders and familiarity of technologies to quantify functional tasks such as gait.

An initial interview guide was developed based on tacit knowledge and experiences of two researchers (AG, RV). Drafts were produced until the researchers were satisfied with the content and phrasing of the questions and prompts posed. During the interview, the researcher (AG) introduced himself, explained the study and obtained written consent from all interviewees. Questions were posed in English using open ended language and in accordance with the semi-structured nature, varied in phrasing and order posed with each participant. Where interviewees failed to fully understand questions, a second researcher (RV) translated into Portuguese. Responses were recorded using an audio device to better understand topics that needed to be translated (by RV) during interviews.

3.0 Results

Those interviewed worked with older adults who experience mobility issues resulting in poor gait and falls, including those with PD. The two interviewees were multidisciplinary clinicians and researchers with backgrounds in physiotherapy and clinical neurology, where the former had wearable technical skills in data analytics and algorithm development. Both (1M/1F) had research experience (5-10years)

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[1] Defined by the Development Assistance Committee (DAC) list of official development assistance recipients.

pertaining to the development and application of inertial wearable in clinical research from different geographical areas in Brazil and Europe. Each interview lasted approximately 45-minutes and were conducted at the Department of Physical Education, UNESP, Rio Claro, Brazil. Upon completion of interviews, a thematic analysis was conducted which uncovered three main themes (as detailed below).

Theme 1. Regional inequalities: Wealth, culture and education

Emergence of this theme by interviewee dialogue captured technology attainment and acceptance when they talked about technology cost and variations between regional states such as wealthier southern states (e.g. São Paulo) compared to poorer northern states (e.g. Amazonas). One interviewee described her knowledge of some research use of perceived low-cost wearables in Europe which don't translate as cost effective anywhere in Brazil, "…*whenever we say R$500* (£80/€100)*, it's not that cheap for us*". Subsequently, interviewees posed cultural and educational (e.g. language and health) barriers. One described use of wearables to assist clinical diagnosis where his perception was that the technology could be met with hesitation and uncertainty from older adults. For example, the physiotherapist described his experience of dealing with his patient's perceptions that physiotherapy is therapeutic only, rather than a need to understand underlying neurological symptoms. "*They* (the patient) *don't understand what assessment is. What are you doing, hooking this device on me asking me to walk? This is physiotherapy*".

Theme 2. Resources and knowledge exchange

Topics relating to robust assessment and quantification of the complete gait cycle to generate clinically relevant digital (bio) markers were discussed. It was generally assumed by interviewees that there is a complete lack of appreciation for this research within Brazil due to a dearth of professional networks to permeate information. Current mechanisms to upskill are at the discretion of the individual only. "*I think, physiotherapists in Brazil don't understand how important it is to have very precise outcomes, that's the issue*". Interviewees also raised the fact that, "*sometimes people* (those with a diagnosis of PD) *are not assessed at all…, people* (publically available physiotherapists) *usually don't assess patients properly, to be honest*". Furthermore, those wanting to complement clinical practise with innovation are met with collaboration barriers and timely administrative delays, which were described as systematic within Brazil. Approaches to multidisciplinary and integrated work were described as lacking, "*…and another thing in Brazil is that engineering is so far away from health,… sometimes health people don't like engineers and the other way round, so it's too far away.*"

Theme 3. Trust, reference standards

The profound factor influencing use of wearables for gait assessment is "*trust*". Current knowledge of gait assessment extends to use of reference standards only (e.g. instrumented walkways and 3D camera-based motion capture systems). Ad-hoc development of wearables, including a plethora of algorithms to quantify gait stemming from EU and US-based studies, has resulted in apprehensiveness for those familiar with the field. When quizzed, one interviewee detailed that wearables "*are not as good as cameras, will not give us same precise data*". When quizzed further, his perception was that "*with wearable you have to build your own algorithm right now and those other devices* (i.e. reference) *you don't, so it's ready – as most people don't know how to process that* (wearable) *data so I will trust what the computer* (reference standard) *is giving me, ..., wearables we are not at that point yet, …, it depends on me to process? So I don't know how to do that so I will trust the computer, the black box and that's it*".

4.0 Discussion

Although current European projects may show gait assessment with wearable technology as a clinical robust diagnostic approach they are grounded in resource-rich regions. Notable pragmatic challenges exist when considering use of the same methods in a country with such large regional inequalities like Brazil. Current EU or US-based approaches in research to utilise low-cost technology for gait analysis may not translate across borders, even those utilising open source components tethered to generic smartphones [15]. Brazil has notable economic inequalities as well as potential challenges to nuanced clinical assessment which may be fraught with cultural and educational barriers of acceptance (Figure 1).

There seems to be disparities between professions within Brazil and a need to instil a culture of multidisciplinary teams working towards the development and deployment of wearables to aid healthcare. Perhaps lack of joined up thinking, negatively impacting shared knowledge for healthcare professionals, contributes to failings to better understand how gait and other traditional assessments could be objectively quantified with digital technology. Integrated approaches and more collaborative efforts between (e.g. healthcare and engineering) professions could lead to greater innovation, stimulating sharing of knowledge to further economic growth for this economy [16].

Given the complexity of normal or pathological gait analysis, abundance of devices, wear locations and complex algorithms developed ad-hoc [17], it is little wonder why wearables lack trust. Typically, gold/reference standards have been the accepted norm, benefiting from a legacy of historical use originating from expensive equipment and used in elitist settings only. Efforts by projects such as Mobilise-D seek to harmonise the field of wearables by developing agreed standards with regulators to establish a new international basis for disease-specific and cross-condition digital (bio) markers. Although difficult to disseminate technology, approaches to share knowledge of how gait could be assessed with wearables may be achieved through multilingual massive open online courses (MOOCs), recently discussed within Brazilian contexts [18]. Global approaches to utilising MOOCs are evidenced through recent dementia care [19]. Additionally, more stringent efforts to guide validation and verification processes with wearables [8] should instil trust, facilitating more pragmatic gait assessment approaches to define healthy ageing in any global region.

Though this case study sought to identify general pragmatic challenges, a limitation relates to the representativeness of our small sample. Recruitment likely resulted in a greater representation of professionals who were more inclined to be knowledgeable of wearable technology-based gait assessment (e.g. involved in previous research on the topic) rather than less informed healthcare professionals. Consequently, the small size limits the ability to explore concordance and discordance among a range of healthcare professionals delivering routine clinical screening of those with PD across Brazil. Future works aims to recruit larger and more diverse numbers to better explore technology use for front-line clinical assessments.

<Figure 1>

5.0 Conclusion

For a geographical diverse, low-resource/middle-income region like Brazil, cultural challenges such as variations between urban and rural life, economic/financial and social factors must be examined when utilising technology at scale. Indeed uptake of technology, even those detailed as low-cost, will have significant functional implications, which may be beyond any realistic use. There is a scarcity of awareness supporting use of any new technologies beyond resource rich regions (e.g. EU, US) for use in less developed regions. Ongoing and future projects should consider the scalability of their technological approaches to gait assessment, for global appeal to aid patient screening and diagnosis.

Contributors

AG and RV contributed to the study design and interviews. AG and RV analysed the data and drafted the manuscript with input from CA, AH, MB and TR. RV translated Portuguese phrases into English. Each author contributed to revision of the manuscript as well as agreeing and approving the final text.

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Ethical approval

The Faculty of Engineering and Environment, Northumbria University research ethics committee granted ethical approval (Ref 9203). Participants gave written informed consent, agreeing to anonymised direct quotes being presented in this text.

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FIGURE

Figure 1: From the Brazilian motto "Ordem e Progresso", order and progress may be achieved in the use of wearables as clinical tools by improved education on the use of technology but challenges exist in a geographical and socially diverse country. Creation of multidisciplinary projects/institutes, better sharing of knowledge/ideas and global initiatives to enable agreed translated standards on wearables and arising digital biomarkers is key.

SUPPLEMENTARY MATERIAL

Appendix A: Semi-structured interview questions

Background	• Please tell me about you and your professional background • What clinical group do you most often examine? • What has been your experience of using technology in your field of work?
Technology awareness	• What can you tell me about your experiences of technology use in your field of work within Brazil? • How would you find out more about current Brazilian-based technology use within your field? • Do you ever investigate technologies that may be used beyond Brazil? • What are the challenges you face to learn about new technologies in your profession?
Gait assessment	• What is the routine clinical protocol/process of assessing gait within Brazil? • What aspects of gait do you try and assess? • What are the challenges you face to use technology for gait assessment during routine clinical practise?
Acquiring knowledge	• Is there a (national) professional network to allow you investigate new innovate methods/approaches? • Is in-depth gait assessment appreciated within Brazil? • How does someone in your profession become more informed on gait assessment?
Current knowledge and experiences	• Can you describe the current state-of-the art for gait assessment? • What is the limiting factor with those technologies and what would be more suitable for current use in Brazil? • What is your knowledge of inertial wearable use for gait assessment? • Can you describe and discuss the assumptions from your profession/work about wearables for gait assessment? • If you tried to use or develop techniques for gait assessment, where were the limitations? What was the greatest problem? • Tell me your thoughts about current approaches to multidisciplinary work in Brazil.
Wearable benefits	• Would data from wearables to assess gait be useful and appreciated by your profession and your patients? • What challenges exist to showcase the benefits of using wearables for gait assessment?